Robert P. Smith
927 15th St. NW
Washington, D. C. 20005
Sept. 9, 1970

Paul L. Hoch
Berkeley, Calif.

Dear Paul:

Bud Fensterwald has consented to let me examine the draft of your thought-provoking paper, "An Experimental Study of the Motion Produced by the Fatal Shot in the Assassination of President Kennedy". I have been interested in this question myself, and having had some training and experience in engineering and physics (now very rusty, I must admit), I have undertaken to review your paper and offer my comments.

First of all, I want to express admiration for your integrity in conducting and reporting such a study. Those of us who disagree with one or more aspects of the Warren Commission's findings are sometimes overly zealous in rejecting the Commission's hypotheses in general, to the point where tend to develop our own blindspots in assessing the evidence. In my view, the Commission's failure to consider and face up to the problem you have tackled, as with some other disturbing questions in other phases of the investigation, is a serious blot on the Commission's integrity and thus on the integrity of the entire nation.

Yet if that blot is to be removed, we must not stoop to depreciate our own standards in searching for the truth. It is thus very much to your credit that you have been willing to entertain, think through, and then advocate a view which tends to substantiate a crucial Commission thesis, however dishonest or incompetent the Commission may have been in arriving at that thesis. Would that the Commission itself had had as much objectivity!

Turning now to the paper itself, I have a number of comments and criticisms, ranging from the nitpick variety to more substantive matters. I offer these in the spirit of scientific conservatism (not to be confused with political or bureaucratic conservatism), and I trust you will take them that way.

1. Recognizing that you probably received no funding for the experimental work, and allowing for the inevitable imperfections of Xerox reproduction of your photographs, I must nevertheless register a complaint about the difficulty of determining exactly what happens in your experiments. A neutral background screen, with a few markers to indicate horizontal distances, might have vastly improved the legibility of your figures. In addition, you could easily have done more in the way of measurement and tabular presentation of data, to show such things as the before and after weights of each target, the sizes and positions of the entry and exit holes relative to the axis of initial alignment, and the observed speed and direction of motion in each case. More replication of the exper-

iments, and the inclusion of some deliberate cases of off-center or tangential impact, would also have been highly desirable. (I have the feeling that the Z313 impact on the President's head was distinctly off-center, for which type of case I would predict that the direction of the shot has less influence on the subsequent motion than the obliqueness and location of the impact.) At a more sophisticated and much more expensive level of experimentation, I should like to have seen high-speed photography to show elastic effects in the shell of the melon, and high-frequency-response pressure instrumentation to measure transient pressures inside the melon shell. Both of these kinds of data, I feel, are needed in order to formulate any reasonably complete explanation of the recoil phenomenon you observed.

2. I am troubled by the magnitude of the momentum in the President's body, as evidenced in the Zapruder film and Thompson's derived data, which you propose to attribute to this phenomenon. As a matter of fact, when I first saw the Zapruder film at the Archives, I had exactly this same objection to those explanations which are founded on the premise of a shot from the right or right-front of the President's car; there is too much momentum in the President's subsequent head and body motion to be attributed to a 160-grain, 2000 fps bullet, even if the bullet transfers all its momentum to the head (no penetration and no spalling), no matter what its direction of origin. The body of a rifleman, which absorbs as much momentum as is imparted to the bullet he fires but in the reverse direction, does not react so violently as does the body of the President in the Zapruder film. An extra source of thrust was necessary to account for the observed body motion even if the shot did come from the right front. Some rough calculations based on Thompson's data (taking into account the President's lateral motion as well as the motion along the axis of the car) indicate a total body momentum of about 200 lb-ft/sec, or roughly four to five times as much as carried by the bullet. (Your corresponding calculation on page 3 of Appendix A1 neglects the lateral component of the body motion, visible in both the Zapruder and Nix films as being equal to or greater than the axial component; in addition, the 1.6 fps average axial speed you obtained from Thompson's data (frames 313 to 321) is appreciably less than the maximum or near-maximum speed attained over frames 315 to 319).

At the time when I made the above observation, I was not of course contemplating the intervention of jet-recoil forces of the type you have observed experimentally. Now that such an effect has been demonstrated, it becomes necessary to contemplate its magnitude in relation to the observations from the Zapruder film to see whether it will pass the test of quantitative prediction any better than the bullet-from-the-right hypothesis.

It would appear, from such data as you report, that the maximum backward momentum you observed was of the order of 18 lb-ft/sec, or somewhat less depending on the amount of material lost from the melon (target #4). This figure falls substantially short of my estimate of 200 lb-ft/sec in the President's head and body motion. Even if we look at the head motion alone, as you have done at the bottom of page 2 of Appendix A1, we would have something of the order of 60 lb-ft/sec of momentum to account for (using the maximum observed speed and combining both components of motion), which is still much in excess of your maximum observation. (Furthermore, I really cannot think of any logical justification for neglecting the President's body motion in any attempt to provide a convincing explanation of what happened. Can you?)

Of course, there is still the inescapable fact that melons are not heads. Furthermore, because of the damnable opacity of the autopsy reports and the senseless obstructionism of the Warren Commission, we do not know enough about the details of the President's wounds. In sum, although your observations are intriguing and possibly on the right track, I don't feel that we know enough yet to say that this question has been resolved. More specifically, I think you have overstepped the limits of your evidence pretty far when you say such things as, on page 17, "White's conclusion ... is basically correct ..." and "We have seen how Thompson came to the wrong conclusions ...", or on page 23, "Our work has demonstrated that the fatal shot probably was fired from the direction of the School Book Depository Building ..." (This latter statement would not be justified even if your physical arguments were quantitatively airtight, in view of the many other rearward locations which might have served as the source of the shots. I am even more confounded by your statement on page 24 that the observations tend to support the theory of Oswald as the lone assassin, inasmuch as the objections to that theory derive from a much larger sweep of evidence than the postulated direction of one particular shot.)

3. I turn now to the question of the possible mechanism for production of the observed backward momentum in your experiments. From a strictly scientific view, this is the most interesting aspect of your observations, in my opinion, and I think it is worth some further back-of-an-envelope type calculations. In several places in your paper you allude to a "rocket-motor" or jet propulsion effect as the probable mechanism. I believe this to be correct, at least so far as the behavior of the melons is concerned. In the case of target #4, with its apparent backward momentum of some 18 lb-ft/sec, I am led to observe that some rough calculations produce some startling results. First of all, Figure 1 suggests that the effective duration of operation of the jet stream is of the order of about 0.2 seconds (roughly five frames as I see it, with near negligible action thereafter). To produce 18 lb-ft/sec of momentum over this period requires an average force of 90 lb-ft/sec^2. If in fact the force decreases linearly with time (which it almost certainly does not, but it may serve as a fair approximation), the initial force would have to be of the order of 180 lb-ft/sec^2. That is a pretty fair amount of force. If it acts through a jet stream exiting from an effective area of, say, two square inches (my guess as to a typical exit hole), the implied internal pressure within the melon is about